U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-260 134

METHODS FOR ESTIMATING COSTS OF INDUSTRIAL WASTE CORRECTIVE MEASURES

PUBLIC HEALTH SERVICE, CINCINNATI, OHIO

3 NOVEMBER 1941

PB 260 134

254032

LIBRARY
SANITARY ENGINEERING CENTER
CINCINNATI, OHIO

INDUSTRIAL WASTE GUIDES

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U. S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

BIBLIOGRAPHIC DATA SHEET	1. Report No.	2.	3. Recipient's Accession No. PB-260 134
4. Title and Subtitle Methods for Estimating Costs of Industrial Waste Corrective Measures			5. Report Date 3 Nov 41 6.
7. Author(s) S. R. Weibel.			8. Performing Organization Rept. No.
9. Performing Organization Name and Address Public Health Service, Cincinnati, Ohio. Office of Stream Sanitation.			10. Project/Task/Work Unit No. 11. Contract/Grant No.
12. Sponsoring Organization Name and Address			13. Type of Report & Period Covered 14.

15. Supplementary Notes

Portions of this document are not fully legible.

16. Abstracts

A discussion of cost estimation methods, prepared in connection with the estimating of costs of corrective measures, Ohio River Pollution Control Report, and based on inspection reports, for use with a lecture at the Public Health Service Training Course for Sanitary Engineers in Stream Pollution Abatement Programs, Environmental Health Center, Cincinnati, Ohio, 1949. Corrective measures and their costs, by type of industry, for the most common and most numerous industrial wastes in the Ohio River Basin are described.

17. Key Words and Document Analysis. 17a. Descriptors

17b. Identifiers/Open-Ended Terms

Ohio River Basin
*Cost estimates
*Industrial waste treatment
Water pollution control
Waste recycling

17c. COSATI Field/Group 13B

18. Availability Statement	19. Security Class (This Report) UNCLASSIFIED	21. No. of Pages 61
	20. Security Class (This Page UNCLASSIFIED	22. Price

FORM NTIS-35 (REV. 10-73) ENDORSED BY ANSI AND UNESCO. THIS FORM MAY BE REPRODUCED USCOMM-DC 8265-P74

ATTENTION

AS NOTED IN THE NTIS ANNOUNCEMENT,
PORTIONS OF THIS REPORT ARE NOT LEGIBLE.
HOWEVER, IT IS THE BEST REPRODUCTION
AVAILABLE FROM THE COPY SENT TO NTIS.

N O T F O R P U B L I C A T I O N

Presented in connection with a lecture at the U.S.P.H.S. Training Course for Sanitary Engineers in Stream Pollution Abatement Programs, conducted at the Environmental Health Center, Cincinnati, Ohio, April 25 - May 6, 1949

METHODS FOR ESTIMATING COSTS

OF

INDUSTRIAL WASTE CORRECTIVE MEASURES

Prepared in connection with the estimating of costs of corrective measures, Ohio River Pollution Control Report

S. R. Weibel

U. S. Public Health Service
Office of Stream Sanitation
Cincinnati, Ohio

October 1941
Revised November 3, 1941

FOREWORD

Considering the date at which this material was prepared, the reader should bear in mind, first, that more recent developments in waste control processes may render obsolete some of the control methods outlined herein, and second, that present day costs are much higher than those used in preparing this material.

INDUSTRIAL WASTE CORRECTIVE MEASURES

CONTENTS

	Page
General	201
Plant Changes	202
Treatment in Municipal Plants	203
Industrial Waste Treatment Plants	204
Installation Cost	205
Annual Charges	206
Interest and Depreciation	206
Operation and Maintenance	
Corrective Measures and Costs by Industries	207
Cannery	208
Milk Plants	211
Paper and Paperboard Mills	214
Save-alls, Recirculation	215
Chemical Precipitation	216
Ponding	216
Filtration	217
Miscellaneous Treatment Information	218
Corrective Measures for Cost Purposes	219
Summary	224
Distilleries	226
Evaporators	226
Disposal to Land or Ponding	228
By-product Coke Plants	230
Steel Industry	237
Textile Mills	240
Packinghouses, Slaughterhouses	242
Corrective Measures & Costs - Miscellaneous	245
Screening	246
Plain Sedimentation	246
Ponding	247
Connecting to Municipal Sewers	248

SECTION TWO

Methods for Estimating Costs of Industrial Waste Corrective Measures

October, 1941, Revised November 3, 1941

General

Cost estimates on industrial waste corrective measures are based on recent cost experience wherever possible. In other cases, cost figures are engineering estimates based on inspections or available descriptions of industrial waste treatment plants. The experience and advice of industrial representatives and equipment manufacturers have assisted in arriving at many of the estimates.

In actual industrial waste treatment practice, each industrial plant receives a detailed study. This condition is approached in the present survey as the inspection reports cover most important features in sufficient detail that each plant can be given individual consideration. However, no effort has been devoted to estimating the cost of separating inoffensive cooling and other water from concentrated wastes, a customary step preliminary to installation of the industrial waste treatment plant.

Corrective measures applied to industrial waste pollution may include one or more of the following procedures:

(1) Changes within the plant to reduce or eliminate the pollutional character of the waste. This can be done by changes in process, development of by-products, and by careful operation.

(2) Treatment with domestic sewage in a municipal plant subsequent to possible pretreatment at the industrial plant and the exclusion of wastes detrimental to sewerage structures and treatment processes.

(3) Treatment of the wastes at the mill prior to discharge to the stream. In some cases the cost of treatment may be substantially reduced by an effective application of procedure (1) above.

Plant Changes

Many opportunities for an economic solution of the pollution problem lie in the reduction of volume and strength of waste by revision of plant waste disposal practices, changes in processes, development of by-products, and reuse of wastes or recovered materials in the plant. At least a partial relief from the expense of correcting pollutional waste discharges should be possible.

While it is not possible to analyze all of the possibilities with respect to changes within the plant, some of the more common by-product recoveries and process revisions to reduce the volume of wastes have been taken into consideration in determining details and cost of corrective measures. These possibilities are covered in later paragraphs under individual industries. Undoubtedly any concerted movement toward an improvement of stream

conditions will encourage the development of many additional methods for correction of wastes within the plant.

Treatment in Municipal Plants

Ordinarily, many industrial wastes can be treated more economically, and in some cases more effectively, at a municipal plant because of the economies and control exercised in larger scale operation. Barring complications in industrial plant-city relations, this solution is the most practical from an engineering and cost standpoint. Wherever industrial wastes are considered as acceptable and accessible to municipal treatment facilities they have been included as part of the cost of municipal treatment. In considering the acceptability of wastes for municipal treatment, due consideration is given to the size of the municipal plant, the type of treatment and the character and volume of industrial waste. Certain wastes, either chemical, organic or inorganic, are excluded from municipal sewers because of possible damage to sewerage structures - such as acids, impairment of treatment processes - poisons such as cyanides, or heavy metals; clogging of sewers or overloading of sludge handling equipment, or caking of sludge,- such as limes, hair, fibre; or concentrated organic wastes which may overload the plant. In many cases discharge to municipal treatment is made possible through the partial or pretreatment

of wastes at the mill to reduce these objectionable characteristics. Such costs are carried as an industrial cost, as are the required industrial connections to municipal sewerage systems.

Industrial Waste Treatment Plants

Industrial waste treatment in a number of industries has advanced sufficiently that effective methods are well illustrated by plants now in successful operation.

In general, the types of industrial waste treatment upon which the industrial cost estimates depend, are based on processes illustrated by successful installations on a commercial scale. This applies to many but by no means all of the wastes requiring industrial treatment consideration in the Ohio Basin. In some cases the type of treatment is not considered a wholly satisfactory solution but is applied as a partial correction pending the solution of technical and financial problems connected with more efficient treatment. Finally, there are some types of waste for which economical treatment methods must be developed. In such cases either a type of treatment based on experimental data or the general character of the waste has been estimated for cost purposes, or the broad policy that all discharges containing objectionable settleable solids be given plain sedimentation as a minimum has been applied.

Installation Costs

Contrary to the situation in regard to municipal sewage treatment, cost data on industrial waste treatment is scarce and fragmentary.

Data on performance and costs for various types of full scale industrial waste treatment processes were derived from industrial reports of the present survey, from a survey of published information and from solicitation of State health departments, consulting engineers, engineers connected with industry, and companies manufacturing or distributing specialized equipment such as evaporators and by-product coke plant equipment.

In the cases where data on actual costs were available (in about half the cases, one for any one type of treatment), engineering cost estimates for the particular type of treatment were made for several capacities and the resulting curve relocated to compare with the actual cost available. In other cases, cost ranges were established from curves based on municipal primary or secondary treatment plant costs adjusted to the available actual industrial cost.

Where no actual cost data were available for representative treatment practice the costs presented are engineering estimates. Such cost estimates are based on the best available data obtained from a review of published contract unit prices, estimates obtained from manufacturers and other published or private sources of cost experience.

The construction cost figures obtained as above were adjusted to total cost by assuming, as has been done for municipal treatment plants, that land, engineering and miscellaneous expenses amount to 15% of the installed construction cost. Actually, land may be available at little or no added cost at many plants while at others this item may be a major factor in selection and cost of treatment. Similarly, engineering services may range from the employment of consultants, to the use of engineering services within the company or industry. However, sufficient data on individual plant circumstances are not at hand to warrant a study of possible variations in this 15% figure and it is considered reasonable for the general case. Contracting profits are also included in the basic construction costs.

Annual Charges

Interest and Depreciation - Fixed charges, including interest and depreciation or amortization on total first cost, is based at most plants on 5% interest and a life expectancy of 10 years. Some exceptions to this are covered in the detailed discussion following.

Operation and Maintenance - Data on industrial treatment plant operating and maintenance costs are very meager. Actual cost data has been used where such information is available. Operating and maintenance costs, in other cases, have been

based on municipal treatment costs for similar sized installations with adjustment for chemical costs. In still other cases, independent estimates have been made.

Operating and maintenance costs are presented on a daily basis and applied in general to the actual number of working days annually indicated in the inspection reports. Where chemical precipitation is applied, it may be possible to reduce chemical costs during high flow periods. No attempt has been made to anticipate such savings in the annual costs estimated.

Corrective Measures and Costs by Industries

Detailed studies have been made of all available information on corrective measures and their cost for the common and most numerous classified industrial wastes in the Ohio River Basin. The costs of such measures are summarized graphically in Figures I-1 to I-5.

Discussions of measures and costs for breweries and tanneries which are numerous enough to be included in the above grouping are omitted. In the case of the breweries in the basins, locations in the larger municipalities make it possible to handle wastes in a municipal treatment plant. Practically all of the tanneries of large size now have varying degrees of treatment and the smaller ones are within reach of adequate suggested municipal treatment facilities. Such individual instances of industrial treatment or pretreatment as are required are handled as special cases. Otherwise, the measures

assigned consist largely of supplementary equipment and plant improvements.

There are other miscellaneous industrial wastes in the basin, some of which, though they may be generally classified by the nature of their business, cannot be so classified for waste correction because of the wide variation in the character of wastes produced and their individual significance as governed by stream circumstances. These are handled as individual treatment problems with an application of corrective measures, including variously screening, sedimentation, flotation, recovery, separate disposal and chemical or biological treatment to part or all of the waste of the individual plant. The measures applied are based largely on available reported corrective practices, proposals or estimates by consultants or industry for the individual plant, or in some cases on measures suggested as a result of reported laboratory or plant investigations. No attempt is made to present a common denominator of cost for this miscellany of individual corrections.

Cannery

Industrial treatment methods for cannery wastes are well represented by numerous commercial installations. The processes in common use include screening, plain settling, chemical precipitation, ponding and broad irrigation, all of which are represented by installations in the Ohio Basin. Secondary treatment on trickling filters is commonly mentioned in the

literature but is not widely represented by practice because of the high cost and the necessity of conditioning before seasonal use. Judging from the extensive use of ponding noted in the survey the problem of space appears to present no difficulties for the small rural cannery and the economy of such treatment presents an attractive opportunity for effective control for the short season cannery. One of the chief drawbacks to ponding is the creation of local odor nuisance. Considerable promise is reported in early season results of the application of sodium nitrate to cannery ponds being tried this season for the control of odor nuisance. While the cost of such control is appreciable, it offers the short season cannery a generally less expensive method of correction than a filter plant in the cases where a high degree of treatment is warranted.

Fill and draw chemical precipitation is also a common type of treatment and is particularly well represented in Wisconsin with over 50 plants. Reasonable in cost and effective in its applicability to most cannery wastes, it appears to offer a reasonable solution for the average case and has been adopted for cost purposes. Where a higher degree of treatment appears necessary, pond capacity equivalent to one-half the seasonal flow has been added to provide additional reduction in the load as discharged, by oxidation, seepage, and controlled outflow. An installation including chemical

precipitation and 15 days ponding followed by a series of ditches, operates during a six weeks season of corn and tomato packing at Mason, Ohio. An overall reduction in B.O.D. loading of 90 per cent is shown by a single analysis taken during the tomato pack.

Construction costs for fill and draw chemical precipitation based on mechanical screening and a 2-hour cycle of mix, coagulate, settle and discharge in a two or more tank plant, with sludge drying beds, were estimated for several installation capacities at an assumed maximum discharge rate of 50 gallons per case per 12-hour day. The resulting curve was adjusted to the upper figure of $3,000 to $4,000 supplied by the Wisconsin State Health Department as the cost for a two-line plant. Ponds following chemical precipitation for further control were estimated at unit prices for 2-foot water depth, full.

Operating and maintenance costs for chemical precipitation are based on data presented in Bulletin No. 28-L of the National Canner Association (Dec. 1939). Pond operating and maintenance costs are considered negligible. In cases where odor nuisance is likely to be of consequence, odor control by sodium nitrate or other means, or trickling filter treatment, should be considered.

The estimated costs, including 15 per cent of the construction cost for land and engineering, are as follows:

Production Lines	Production Cases per day	Average Waste Flow Gallons per 12-Hour Day	Total Installed Cost Chem. Precip.	Ponding 15 Days	Ponding 30 Days	Daily Operation and Maint.
1	500	12,500	$2,900	$1,000	$1,300	$8.00
1	1,000	25,000	3,500	1,300	1,800	9.50
2	2,000	50,000	4,600	1,800	2,400	13.00
3	3,000	75,000	5,800	2,100	2,900	16.50
4	4,000	100,000	6,700	2,400	3,300	20.50
5	5,000	125,000	7,500	2,700	3,700	24.00

The above costs may be applied to the individual plant on a line, case, or flow basis, preferably flow, depending on data available, and adjustments made for individual plant characteristics.

An overall treatment removal of about 50 per cent in biochemical oxygen demand loading may be anticipated with properly applied fill and draw chemical precipitation, and upwards of 75 per cent when followed by ponding to regulate discharge to one-half or less of the seasonal inflow rate. In assuming pond capacity no allowance has been made for oxidation and seepage.

Milk Plants

It is not proposed under any method of treatment, industrial or municipal, to provide for intentional discharge of whey, buttermilk, skimmed milk or whole milk. The development of by-product uses and separate disposal to farmers or land has now become a common practice in the Ohio River Basin as elsewhere.

Processes of treatment in common use at milk handling and processing plants include septic tanks, trickling filters, activated sludge, Guggenheim process and broad irrigation. All of these are represented in the Ohio River Basin. There is also a cream, casein, whey powder plant in the basin which disposes of casein and whey plant wastes to leaching gravel beds and treats creamery wastes by chemical precipitation using lime, marl and copperas.

The bulk of the milk plants surveyed, particularly the large plants, are so situated so that they will be accessible to municipal treatment. The plants remaining for industrial treatment considerations are substantially small cheese factories and small to medium miscellaneous milk plants.

The trickling filters appear to be the most suitable and common method of effective correction for installations in this range. Installation costs are generally higher than for the other refined processes but the dependability and relatively simple and economical operation of the trickling filter makes it generally preferable.

Several ranges of trickling filter installation costs were available from the literature, the Wisconsin State Health Department and the Carnation Company (which acts as engineer and contractor for its many trickling filter installations throughout the country). These, together with

estimated costs for several capacities were used to determine a curve of construction costs to which the 15 per cent land and engineering adjustmemt was added. Op rating costs are estimated with the guidance of some actual costs in the upper ranges.

The resulting costs are:

Milk Intake (1) Pounds per Day (Flush Season)	Estimated Average Waste (2) Flow to Treatment Gallons Per Day	Trickling Filter Plant Costs	
		Total Installed Cost	Daily Operation and Maintenance
20,000	3,200	$4,000	$1.50
50,000	8,000	5,500	1.92
100,000	16,000	8,000	2.60
200,000	32,000	11,500	3.84
300,000	48,000	14,500	5.20

(1) Generally applicable for all types of plants except cheese factories. In applying cost table to cheese factories the installation cost corresponding to the actual flush season cheese factory intake should be approximately doubled (to provide for the additional filter capacity required on a B.O.D. loading basis). No such adjustment for operating cost need be made since the average cheese plant waste flow approximates those given in the table, so that pumping, etc. would therefore be the same on an intake basis.

(2) Does not include inoffensive cooling waters, nor contemplate treatment of any products or by-products except those incidental to washing operations.

Since many of the milk plants, even though small in size, discharge to ditches and small watercourses, secondary treatment equivalent to the above is required to abate local nuisances. In some cases the cost applied represents the addition of filters to existing septic tanks. There are a

few plants, however, discharging to streams of sufficient size that correction by primary treatment appears sufficient. In such cases the cost of sedimentation is assigned.

Paper and Paperboard Mills

A review of sources of information on the treatment and disposal of paper and board mill wastes indicates that the bulk of reported actual practices revolve around the saving of fibre from machine wastes. At paper mills working with clean raw materials, or at most board mills, recovery and recirculation, or recirculation alone may constitute an effective means of reducing the obnoxious effects of the raw wastes. The recovery of fibre and partial recirculation of machine wastes back to the process is probably as common a practice in the Ohio Basin as elsewhere for similar mills. However, many of the mills in the basin include in their process the preparation of rags, rope and old paper. Mills processing dirty rags as part of their paper making operations may have wastes from rotary boilers, washers and beaters constituting in the neighborhood of 70 percent of the total population equivalent B.O.D. loading as compared with the 30 per cent machine waste loading usually discussed in treatment references.

A review of actual practices discloses methods of correction as follows:

Save-alls, Recirculation - Screens, vacuum filters, flotation and sedimentation devices on machine wastes at paper and board mills are common. Recirculation of machine wastes with or without save-all clarification is also common. Reported practices at three Pennsylvania board mills effected reductions of from 39 per cent to 85 per cent of the population equivalent (biochemical oxygen demand) discharge loading by save-alls plus recirculation in a partially closed system and 90 per cent and over at three other board mills having closed systems and sedimentation of weekly or other intermittent cleanup wastes. Reductions at three Pennsylvania paper mills were reported as 64 per cent, at a mill making fine paper and using a save-all and partially closed system; 50 per cent by the same method at a tissue mill; and 79 per cent at a towel mill.

Many of these practices are represented at Ohio Basin mills, In some cases where the stream is small and the mill large, or where mills concentrate in a short stream section, the residual waste loading from these practices becomes of consequence. In general, it appears that these practices can be applied with high overall efficiencies to board mills where suspended matter can ordinarily be returned to the product, and to paper mills working on clean raw material such as wood pulp, paper shavings and clean rag stock or pulp, in contrast to those cooking dirty rags or rope or de-inking and pulping waste paper,

or those having color change complications. In the case of the latter, recirculation and recovery as commonly applied effects a machine waste correction only. The correction of wastes from rotaries, washers and beaters becomes a treatment problem with little prospect of economic recovery at this time.

Chemical Precipitation - Chemical precipitation applied to a Pennsylvania board mill gave a 70 per cent improvement in population equivalent discharge loading.

A Michigan mill making tarboard automobile strips on a wet machine and boxboard, wrappers, asbestos board, etc., on a dry machine treats these wastes separately and returns the sludge to the respective process. Biochemical oxygen demand reductions of 63.5 per cent and 63.8 per cent for the wet and dry machine wastes respectively, were obtained.

An Indiana mill manufacturing grease proof, glassine, and manifold paper from sulphite pulp treats all wastes with alum in the first of three ponds. Sludge is dried on beds. Pond effluent is recirculated to the process. The replacement cost of the system including save-alls is estimated at $50,000. Production is 18 tons per day.

Ponding - An Ohio board mill producing paper board from wood pulp, paper shavings and newspapers (de-inked at mill) discharges beater washes to a seepage pond. Machine wastes are recirculated.

Another Ohio board mill using wood pulp, paper shavings and waste paper, provides pond detention for 10 per cent of the machine waste and part of the sludge from multiple sedimentation of 90 per cent of its machine wastes. The bulk of the sludge is returned to the process. About 80 per cent of the waste water is recirculated.

A large Pennsylvania pulp and paper mill has provided a reservoir having a capacity 60 times the daily discharge of its de-inking wastes and wash waters from the used peper department. The pond effluent discharges 1.4 miles down a steep channel to the river. The raw wastes average 60 p.p.m. B.O.D. and the wastes entering the river about 14 p.p.m. or an overall reduction of 77 per cent.

Filtration - No mills at present using filtration have been noted. Two Massachusetts mills which have discontinued filtration since the extension of the Boston Metropolitan District Sewer, had treatment facilities as follows:

The one manufactured manila and other paper from rope, bagging, and wood pulp. Machine wastes were recirculated to the washers. Cinder filters received all the settled washer waste and as much of the settled beater waste as they would take. Rotary liquor was discharged either on the drying sludge or on the cinder filters with a lowering of their efficiency. Operation subsequent to connection to the Metropolitan Sewer consisted of discharge of oily rope beater wastes

(3) beaters) to the Sewer and discharge of the settled waste from 19 other beaters to the river. Sludge was discharged to the sewer. Save-all material was burned.

The other mill produced heavy paper boxes, shipping cases, cartridge papers, etc., from cotton and hemp stock. Machine wastes were settled with alum by fill and draw operation with a return of sludge to the process and discharge of the effluent to the stream. Boiler liquors were discharged to waste land. Washer waste was plain settled and filtered on sand. Sludge was dried in beds. Practice subsequent to the extension of the Metropolitan Sewer was the discharge of all but machine wastes to the sewer. Treatment of the machine waste as above was apparently continued.

Miscellaneous Treatment Information - Comments on rag and de-ink wastes by C. L. Siebert, Pennsylvania Department of Health, are as follows:

> "A few mills in Pennsylvania produce pulp by digestion of rags or old rope with a caustic solution. The wastes from such a process are extremely high in pollution load. Two small mills are entirely disposing of rag digester wastes by discharge to leaching pits, but, because of the jelly-like deposit produced, it is doubtful if such method will prove permanently satisfactory unless occasional complete cleaning or construction of new leaching basins is a practical solution. One mill attempted to evaporate digester wastes for recovery of caustic but found that foaming in the multiple effect evaporator could not be successfully controlled. A mill which digests old rope, after indifferent results with acid coagulation, has met with rather marked success by calcium chloride coagulation

of the wastes in batch of fill-and-draw treatment, with absorption of the clarified or supernatant liquor in loose gravel soil and drying the settled sludge in a sludge bed in natural formation.

"A number of paper mills de-ink magazines and similar used paper to produce a pulp which is mixed with new pulp in the manufacture of magazine and some book paper. The de-inking process involves the use of strong chemicals such as caustic soda and the waste waters produced are very high in pollution load. No conventional method for treatment of these wastes appears to have been developed, but chemical coagulation and sedimentation have been shown to be effective although expensive. At Johnsonburg the de-inking wastes and wash waters from the used paper department are impounded in a reservoir having a capacity 60 times the daily discharge and the effluent flows thence 1.4 miles down a steep channel to the river. The raw wastes average about 60 p.p.m. B.O.D. and 250 p.p.m alkalinity (M.O.) with pH values between 7.0 and 8.0 The wastes entering the river average about 14 p.p.m. B.O.D. and 6 p.p.m. D.O."

Adoption of Corrective Measures for Cost Purposes - In considering the practical aspects of assignment of specific corrective measures, it becomes evident that the general lack of application of available corrective measures in practice to wastes other than those from which an economic return may be expected, and consequently the scarcity of loading and performance data, considerably handicaps an effort to assign and anticipate the degree of performance of available measures for many types of mill, particularly those processing rags and old paper. It is also evident that in places where a high degree of correction appears warranted, the cost of correction may range from one extreme to the other dependent, not only on the type of mill process, but on the choice of available corrective measures.

While recognizing the possibilities of a high degree of correction either by large ponding capacity and controlled outflow, or by intermittent sand or cinder filtration for individual cases, it has not been considered feasible to specify these measures and their divergent costs for the following reasons.

Sufficiently detailed data on mill locations, topography, space and other local contingencies are not available within the scope of the survey to propose large ponding facilities at a speculative cost for the specific solution; in the cases where local conditions permit it, ponding with a program of effluent control synchronized to the characteristics of the particular stream should be an economical solution. The problems of space and local environment inherent in pond considerations apply equally to intermittent filters as a specific proposal. In addition, the cost of such treatment is such that an extensive examination of economic possibilities in process changes at the particular mill and detailed analytical study of the receiving water, mill wastes and pilot performance of other less expensive facilities, including those now applied to varying degrees, as applied to the particular mill, would be warranted. Since such a study for the individual case is not available the proposal of expensive intermittent filters as a specific solution also appears unsound.

As an alternative to the specific proposal of ponds or filters and their costs for such cases requiring a high degree of treatment it is proposed that the cost of partial correction included in the report be considered an initial step pending investigation of specifically applicable refined measures. The foregoing applies to the few cases where the character and size of the mills and stream circumstances are such as to warrant a high degree of control. In most other cases the corrective measures indicated in the following paragraphs should provide an effective solution.

The corrective measures adopted for cost purposes and based so far as possible on the practices aforementioned, supplemented by information presented by engineers interested in this field, are as follows:

The revision of machine piping and appurtenances to recirculate all or as much as practical of the machine wastes back to the process. Apparently board mills so corrected may be operated with reduced waste flows ranging from 14,000 gallons per ton to substantially zero in a closed system with weekly or other intermittent cleanup discharges, while paper mills can, by partial closure, greatly reduce the volume of waste discharged. Data collected in Wisconsin paper mill studies "....bears out the contention that most any paper mill can operate with a fibre loss to the sewer not exceeding 1 per

cent (of production) and a waste flow of 20,000 gallons or less per ton of finished product". C. L. Siebert, Pennsylvania Department of Health, is convinced that 10,000 gallons per ton and 1/2 per cent fibre loss is possible without hardship. It is proposed for estimate purposes that the average board mill reduce its residual discharges by recirculation revisions to at least 10,000 gallons per ton and the paper mill to 20,000 gallons per ton. The cost of machine revisions for recirculation obtained from C. M. Baker, Consultant in the paper field, is $4,000 per machine. The figure $5,000 per machine is applied to plants in the Ohio Basin as the complete cost of this correction. In cases where the individual plant report indicates recirculation and reduction of flow in the range of those proposed, the cost is not applied.

As indicated by performances at three Pennsylvania board mills the population equivalent (B.O.D. basis) loading residual to a partially closed system averages about 25 P.E. per ton of board, or a reduction of about 73 per cent of the initial 93 P.E. average for these mills. Since the unit loadings assigned board mills of the Survey were about 100 P.E. (B.O.D.) per ton the residual of 25 represents a 75 per cent reduction. In many cases this offers an acceptable solution for the board mill from a B.O.D. standpoint. With respect to fibre losses (as volatile suspended solids) the percentage reductions surprisingly are lower, particularly where no

save-alls are used. In some cases local conditions as regards sludge bank formation may necessitate further correction in this respect. Facilities for chemical precipitation during critical low flow months and plain sedimentation the remainder of the year appears to be a feasible method of reducing the pollution effects of continuous residual discharges, or intermittent discharges due to cleanup or stock dumps on color changes.

The same considerations substantially apply to paper mills working on clean raw materials. Judging from the results of recirculation at three save-all equipped Pennsylvania paper mills manufacturing towels, fine paper and tissue respectively, and having partial to almost complete closure, considerable reduction in B.O.D. loading (50 to 79%) is possible, Percentage reductions in fibre losses were more comparable on the average to those of B.O.D. loading. Consequently, recirculation may constitute an acceptable solution in some cases. However, since many of the Ohio Basin mills pulp rags and old paper as part of their process, the residual washer waste loadings are likely to be high because of pulping wastes, regardless of the disposition of rotary liquor and stock drainings. For such mills facilities for plain and chemical sedimentation appears to offer the best general solution. While B.O.D. removals in the sedimentation units

as applied to the partially corrected wastes are not expected to be large, the facilities offer relief from washer and beater suspended matter and provide safeguard against direct discharge during system cleanups and stock dumps on color changes. Chemical precipitation is one of the two proposals for the solution of de-ink waste problem noted thus far, the other alternative being long period impoundment.

Where mill processes include rag cooking there appears to be no industrial treatment process, except pending thus far noted in which boiler liquor and stock drainings can be accepted along with other wastes without harm to the efficiency of the process. Separate disposal to land, to drying sludge or intermittent filters, to leaching pits, and to fill and draw chemical coagulation with calcium chloride followed by soil absorption, sum up the industrial disposal possibilities with present knowledge. For the purposes of this report it is assumed that boiler and drainer wastes may be discharged to drying sludge at no additional disposal cost. In some instances these relatively small volumes of waste could probably be taken into a municipal system as is now done at Dayton, Ohio.

Summary - A tabular summary of the corrective measures for paper and paperboard mills adopted for the purpose of estimating costs of remedial measures and the basic costs of these measures are as follows:

Corrective Measures

A. Board Mills

(1) Partial Correction - Recirculation.

(2) More Complete Correction - Step (1) followed by chemical precipitation on the basis of assumed 10,000 gallon per day residual waste per ton of product.

B. Paper Mills

(1) Partial Correction - Recirculation - confined as a satisfactory partial correction to mills not cooking rags nor cooking or de-inking old paper.

(2) More Complete Correction - Step (1) followed by chemical precipitation on the basis of assumed 20,000 gallons per day residual waste per ton of product. Suggested as a first step pending investigation of more efficient processes in some cases.

Estimated Costs

Recirculation improvements - $5,000 per machine installation cost. It is assumed that the saving in water and materials will at least defray operating costs. The total charge to pollution abatement is represented by fixed charges.

Chemical Precipitation

Mill Production Paper Tons/day	Board Tons/Day	Corrected Waste Flow M.G./24 hrs.	Total Installed Cost	Daily O. & M. *
25	50	0.5	$30,000	$19.
50	100	1.0	45,000	33.
100	200	2.0	70,000	60.
250	500	5.0	155,000	143.

* Including cost of chemicals

Distilleries

Seventy-one distilleries were covered by the survey. Practice reducing the pollutional loading discharged to streams at over 80 per cent of the plants were reported as follows: Disposal of excess slop to farmers; to cattle penned in the vicinity for the purpose (pen effluents variously ponded, pumped to land or allowed to reach the stream); evaporation of slop; ponding or broad irrigation. Screens and dryers were in use at most plants. No other commercial practices in reduction of loadings have been noted, in the Ohio River Basin or elsewhere. Wash waters and tailings are commonly discharged to the stream and constitute substantially the total pollutional discharge at some plants.

The remedial measures proposed for cost considerations are (1) evaporators at large distilleries and (2) ponding or disposal to land at small distilleries.

Evaporators - The evaporation of slop, tailings and washes at distilleries mashing 1,000 or more bushels of grain daily is proposed. It is claimed in some quarters that a profitable recovery results from evaporation, and in others, that the installation is not warranted on the basis of profi motive alone. In the case of the latter, it is claimed that because of the high cost of evaporator recovery the total net operating profit from investment in screening, drying and evaporator

equipment would be the same as that which can be obtained from the dryhouse installation of screens and dryers only.

A reduction of over 95 per cent of the sewered population equivalent biochemical oxygen demand loading to the stream should result from evaporation if slop were originally discharged to the stream. For plants now disposing of slop other than to the stream the net reduction in population equivalent loading to the stream would be about 50 or 60 per cent, considering original wastes as wash and tailings, and the corrected wastes to be the distillate from slop, tailings and washes. However, in the latter case the resulting improvement over a period of time would certainly exceed 50 or 60 per cent since it was evident from the survey that cattle pen effluents could reach the streams and that slop discharge directly to the stream in times of lack of farmer demand or for other reasons, was likely, and not uncommonly evident.

The estimated cost of evaporator installations, including boilers, evaporators, additional dryhouse equipment, buildings and miscellaneous items based on manufacturers estimates are as follows:

Daily Operation Bushels Grain Mashed	Total Installed Cost
1,000	$ 55,000
2,000	80,000
3,000	100,000

Disposal to Land or Ponding - Evaporator installations for small distilleries are reported not practical and it has been assumed that other correction must be applied to distilleries mashing less than 1,000 bushels grain daily.

Disposal of slop by sale to farmers is a highly desirable and economical practice but has its limitations in fluctuating farmer demand and some objection to rye slop. In either case, at least an intermittent dumping of slop can be expected. In addition to this, the washings and tailings are not commonly disposed of in this way although one plant apparently puts all wastes in its sales tank.

Disposal of slop to penned cattle is another common practice which, while not too satisfactory from a local nuisance standpoint, does effect a considerable reduction in the slop B.O.D. loading judging from an incomplete sampling study in one case.

In each of these cases, an additional method of disposal as a safeguard to the stream appears desirable. While most of the small distilleries in the basin use one of these two partial disposal practices followed in some cases by pumping to land or ponds, there are several distillers at which neither the above or other corrective measures are taken. Final disposal to land or ponds, possibly with outflow control, are the only methods illustrated by practice. This method, while

widely represented in practice, has not been highly successful nor particularly desirable because of faulty design or poor maintenance resulting in washes and overflows to the stream and because of local odor and fly nuisances. Therefore, while this method is applied as a general correction for the purposes of the Report, it is done so with reservation and necessity because of lack of more desirable representative practice. No doubt in many cases local conditions will permit land or pond disposal to be effectively applied. In other instances where local contingencies preclude its effective application consideration might be given to the use of high rate recirculating single or multiple filtration, or the process of anaerobic decomposition. Pilot plant studies of both of these methods have been made with promising results.

The cost of land or pond disposal estimated for the general case includes facilities for pumping and delivering all wastes 1/4 mile to land or pond. In the absence of actual cost data, cost estimates of pumping and piping facilities were made to which were added the cost of prepared land. Allowable land loading was assumed as an average 10,000 gallons per acre per day and the cost of acquiring and preparing land and distribution system as $1,000 per acre based, because of lack of local cost data, on reported Berlin, Germany, sewage farm costs of $764.58 per acre for specially prepared land. The

cost of ponds, considering percolation, pond oxidation and outflow control, to carry over most low flow periods, should not exceed the cost assigned to broad irrigation and the costs assigned are considered within the limits of the accuracy of the estimate to approximate either correction.

The costs presented herewith represent the correction for small distilleries discharging all wastes to the stream, including those not at present providing protection against sales slop discharges or cattle pen effluents. Since many of the small distilleries in the Basin report having facilities for such protection to varying degrees of satisfaction, the application of individual corrective measures and costs vary from improvements to existing practices to the complete correction indicated below.

The costs so estimated are as follows:

Distillery Operation Bushels Grain Mashed Daily	Cost of Land or Pond Disposal	
	Total Installed Cost	Daily Operation and Maintenance
500	$3,600	$1.65
750	4,300	2.17
1,000	5,000	2.70

By-Product Coke Plants

Due to process methods, recovery practices and characteristics of the wastes, miscellaneous correctional measures are customarily applied to the separate wastes. For the sake of clarity in presenting methods and costs of correctional measures,

the individual wastes produced by the usual by-product coke plant are listed below:

Waste	Amount G.P.D./Ton Coal	Characteristic
Ammonia Still	22	4000 p.p.m 5-day B.O.D. 2000 p.p.m. phenol
Final Cooler	315	220 p.p.m. 5-day B.O.D. 100 p.p.m. phenol
Benzol Carrying	15	650 p.p.m. 5-day B.O.D. 70 p.p.m. phenol.
Spent Acid	Small	
Spent Caustic	Small	
Pure Still Residue	0.6	
Quench to Atmos.	125	
Residual Quench	475	
Cooling Water	3200	

Based on limited available analytical data the population equivalent B.O.D. breakdown on the total wastes is as follows:

Waste	Pop. Equiv. (B.O.D. basis) per ton coal carbonized daily
Ammonia Still Waste	5
Final Cooler "	4
Benzol Carrying "	1
All other by difference	5
Total	15

A review of existing disposal practices at the plants surveyed in the Ohio Basin indicates that, with the exception of a few small plants and two large plants for which details could not be obtained, practically all of the plants report facilities or practices for at least partial correction of their waste problem. These measures are variously:

By-product recovery of Ammonium Sulphate, Tar, Benzol Toluol, Xylol, and coke breeze.

Phenol recovery at some plants, by either the Koppers process or the benzol extraction process.

Ammonia still wastes, variously: used for quenching, discharged to slag dump, distilled and the distillate containing phenol used for quenching - in this way corrosive salts are kept from the quench system.

Final cooler water is cooled and recirculated in a closed system with discharge to dump when high in solids. It is also used for quenching. The quantity of waste produced without recirculation, however, is apparently much larger than that volatilized in quenching.

Quench water practices vary from the use of the plant water supply to the use of quench substantially made up of waste, including variously, ammonia still waste, benzol plant waste, final cooler water, and agitator wastes. Some quench systems are entirely closed with recirculation of residual water and recovery of coke breeze.

Acid sludges and benzol still residues are burned, discharged to dump, or used for quenching.

At least one plant has a gravity separator on its benzol recovery unit.

Considerable attention has been paid to phenol and its reduction by recovery. In the Koppers vapor-circulation

process as applied to ammonia still liquors, the phenol removals in the dephenolizer ranging from 80 to 96 per cent and overall removals of from 90 to 98 per cent are indicated in data available. The benzol extraction process applied to ammonia liquor ahead of the still gave an overall removal of 97 to 99 per cent at one plant. While the recovery of ammonium sulphate is a very common practice, the recovery of phenol for economic return alone does not appear to be borne out by common usage, although a dephenolizer at a large plant has been remarked as being installed for the purpose of phenol recovery and not waste disposal. In another instance an installation of the benzol extraction processwas said to break even on operating costs through the sale of phenol but not on fixed charges. Since the ammonia liquor phenols probably constitute more than half of the phenols produced, the reduction is significant, but is apparently not a complete correction. The other large phenol bearing waste, final cooling water, appears to be too large in volume to be entirely dissipated in industrial coke quenching. Correction of this waste by partial or complete recirculation offers a reasonable correction and is in use at some plants.

The removal of B. O. D. from coke plant wastes has received less attention, with the result that little is known about the B.O.D. removals accompanying phenol recovery

or other practices. It has been stated that B. O. D. removal by the benzol extraction process is considerably less than that of the phenol. However, practices such as recirculation of final cooler wastes in a closed system and the use of ammonia still wastes, and such other wastes as feasible for quenching in a closed system, should, by physical removal, effect a reduction of upwards of 60 per cent of the uncorrected total B.O.D. loading. This method appears feasible and is represented by actual practice where a non-domestic coke is produced.

In the case of domestic cokes, objections are raised to phenolic odors resulting from quenching with wastes. Experimental work with chlorine has resulted in the suggested treatment of either the ammonia still waste or the domestic coke with chlorine, with a conversion of phenol to trichlorphenol and a resulting dissipation of most of the objectionable phenol odors. The practicability of this method as regards substantial relief of all objectionable odor and the operating cost involved has not, as far as known, been demonstrated by actual practice. However the use of a phenol recovery unit on ammonia liquor wastes should offer a possibility in this respect.

For the purpose of estimating costs the composite correction is assumed to consist of the following:

(1) A closed quench system utilizing ammonia still wastes and as much other contaminated waste as practicable. The cost of this correction for a plant now quenching with fresh water and recovering breeze would be that of the construction of a small pump sump, connection to quench station sewer and reconstruction of the plant piping system to deliver wastes to the quench station. The latter item may be very expensive judging from one known case and may involve operating expenses where pumping is required. Individual plant details are not available to estimate such changes and this item is not considered in the expense of correction. Little increase in investment charges other than the collecting system should be involved in the correction because pumping facilities are usually required for the fresh water quenching system and the cost of a pump sump and sewer connection should be very small.

While operating costs, exclusive of those where pumping in the collecting system is required, should not increase appreciably, there would likely be an increase in maintenance costs. At one large plant quenching with wastes the maintenance expense is reported to average $5.48 per day per 1000 tons daily coal carbonizing capacity. The life of quench equipment has been estimated at 7 to 10 years using clean water and 2 to 4 years when using phenolic wastes for quenching. If

the maintenance charges are assumed as inversely proportional to the useful life, the relative maintenance charges for quenching with wastes would be about 3 times those for fresh water quenching or on the basis of the above cost, an increase of $3.65 per day per 1000 tons daily coal carbonizing capacity. For the purposes of estimate it is assumed that, exclusive of the expense of a collecting system, the increase in investment is negligible and that the total additional charges are roughly $4.00 per day per 1000 tons daily coal carbonizing capacity.

(2) In the few cases where a domestic coke is produced the correction estimated for cost purposes includes a phenol recovery unit on ammonia liquor wastes. It is assumed that the operating and maintenance cost of the phenol recovery unit would be met by the return on recovered phenol but that fixed costs are chargeable to pollution abatement. The costs of such units estimated from cost approximations furnished by equipment manufacturers in this specialized field are as follows:

Tons Coal Carbonized Daily	Installation Cost Dephenolizer
500	$35,000
1,000	35,000
2,000	60,000
3,000	83,000
4,000	103,000
5,000	115,000

(3) A closed system with cooling tower on final cooler wastes. The total charges of such a closed system are assumed to be chargeable to pollution abatement. The estimated costs of such a system based also on limited manufacturers' cost approximations are as follows:

Tons Coal Carbonized Daily	Installation Cost Closed Final Cooler System	Approx. Daily O. & M.
500	17,000	$3.25
1,000	25,000	6.50
2,000	42,000	13.00
3,000	(58,000)*	19.50
4,000	(72,000)	26.00
5,000	(83,000)	32.50

* Extension of estimated costs.

(4) Separate disposal to land or burning for residues and waste components not feasible for use in the quenching system. No estimate of cost is included.

Some or all of the above measures are applied at present to many of the plants in the Basin and in most cases the costs applied are adjustments based on the above to allow for existing measures in the individual case.

Steel Industry

The disposal of acid pickle liquors is the problem considered in this discussion. Wastes from other plant processes are quite generally subjected to recovery or disposal practices which render them unobjectionable. In isolated cases considerable quantities of scale or flue dust may be

discharged to streams; correction of such conditions will be priced on the basis of plain sedimentation. Wastes from the production of coke are discussed elsewhere in this report.

A number of processes for recovery of usable by-products from spent pickle liquor have been developed. All of the processes are expensive, and the demand for the products is definitely limited at present; consequently, it cannot be recommended that these recovery methods be universally adopted.

The simplest method of treating waste pickle liquors is by neutralization with lime or ground limestone followed by sedimentation, with no attempt made to recover by-products. A number of such plants are now in operation, and, while not entirely satisfactory, it is the most practical corrective measure available and is used as a basis for estimating the cost of treatment.

The plant, as roughly designed for cost estimation, consists of a storage tank for equalizing the flow of pickle liquor and rinse water; storage bin and crusher for limestone; solution feeders and mixing tanks with air injection and mechanical agitating equipment; and final discharge to one of two settling basins operated alternately with periodic shutdown for sludge drying and removal.

Cost estimates on plants of similar design were received at Cincinnati with industrial waste reports from two steel mills. These estimates were made by consulting engineering firms and were used in conjunction with equipment cost data

to price installations for handling flows of from 20,000 g.p.d. to 300,000 g.p.d.

The estimated costs, including 15 per cent for contingencies and engineering, are as follows:

Ave. Waste Flow* Gals./24 hr. day	Total Installed Cost	Daily Operation** & Maintenance
20,000	$ 6,400	$ 3.50
100,000	13,700	4.30
200,000	21,000	7,00
300,000	29,000	9,50

* Includes pickle liquor and rinse water.
** Does not include the cost of limestone.

The quantity of limestone required has been computed from the amount of acid used since complete neutralization of the waste H_2SO_4 and $FeSO_4$, the equivalent of neutralizing all of the acid applied to the process, is contemplated in making the cost estimates. Assuming a limestone of 95 per cent purity and a quantity 10 per cent in excess of that theoretically required, the ratio of limestone to sulfuric acid is 1.2 to 1. The cost is estimated at $4.50 per ton including labor and power for grinding and the charges will greatly exceed those shown for operation and maintenance.

Most of the mills in the Ohio Basin will fall within the range 20,000 - 300,000 g.p.d. In very few instances the discharge of acid wastes may be in excess of 1 M.G.D. Because of the small number of such large plants, the cost curve has not been extended to include them. Each will be considered

as a special case.

For flows of less than 20,000 g.p.d., the installation has been simplified to include only one tank which serves for both storage and mixing. Lime is assumed to be the neutralizing agent and will be fed to the tank by gravity. A simple propeller-type agitator is used to obtain thorough mixing. The neutralized solution may be discharged directly to the stream in most cases although extreme low flows might necessitate separate sludge disposal. Installation of equipment for this type plant can be made for about $65.00 per 1000 gallons of liquor treated daily. It is believed that lime will be cheaper than ground limestone for small plants and the quantity required is estimated from the amount of acid used, as for the larger plants. The ratio of lime to sulphuric acid is approximately 0.73 to 1. The system is designed for intermittent operation, requiring attention for only a short time each day, and power requirements are insignificant. The cost of lime ($15.00 per ton) may reasonably be assumed to represent the total operating cost.

Textile Mills

The survey indicated practically no industrial treatment of textile wastes in the Ohio Basin. Inspection reports on 139 mills in the Basin, including several manufacturing rayon, indicated the industrial treatment to be: neutralization,

flocculation, or mixing, respectively, followed by sedimentation, at 3 mills manufacturing rayon; screening for fibre recovery at a woolen mill; and disposal by ground seepage at a small mill. Most of the mills are small and so located that they are accessible to, or are now connected to municipal sewerage systems in towns which can absorb the wastes in a municipal treatment plant without great difficulty.

Representative practices elsewhere indicate chemical precipitation with facilities for equalizing the wastes to be a common method of treatment, and one favored by various authorities. According to C. L. Siebert, Pennsylvania Department of Health, chemical precipitation as applied to textile wastes, in general, is considered to be capable of ordinarily removing 80 to 90 per cent of the oxygen consuming material from the stronger wastes (B.O.D. of 800 p.p.m. or over) and 60 per cent from the weaker wastes (B. O. D. of 200-300 p.p.m.). In some instances chemical precipitations have been supplemented by spray aerators, air jet mixing and flocculation, trickling filters and rapid sand filters.

Fill and draw chemical precipitation is generally applied to the smaller plants and would be applicable to about 80 per cent of the mills in the Ohio Basin not accessible to present or future municipal treatment facilities. The remaining 20 per cent, because of their size, would probably operate continuous flow plants.

In the absence of representative actual textile waste treatment costs for chemical precipitation, engineering estimates have been made for cost purposes. Fill and draw chemical precipitation plants have been estimated on the basis of a 2-tank plant with a 5-hour cycle of mix, coagulate, settle and discharge. The continuous flow plant estimates include a 5-hour equalization tank followed by mechanical mixing, coagulation and 2 hours settling with continuous sludge removal. Sludge beds are included in both cases. The costs include 15 per cent of the installed cost for land, engineering, etc.; operating costs include chemicals.

Fill and Draw Chemical Precipitation

Flow Gallons per 10-hour day	Total Installed Cost	Daily Operation and Maintenance
10,000	$ 2,200	$ 5.20
25,000	3,100	6.75
50,000	4,600	9.30

Continuous Flow Chemical Precipitation

Flow Gallons per 10-hour day	Total Installed Cost	Daily Operation and Maintenance
100,000	$17,000	$13.00
250,000	30,000	24.00
500,000	43,000	43.00
1,000,000	75,000	80.00

Packinghouses, Slaughterhouses

With few exceptions the larger plants, packinghouses, in the Ohio Basin are so located that they can be connected to

municipal systems and treatment. The bulk of the meat plants encountered were small slaughterhouses, some of which are not within reach of municipal systems and will require separate correction.

Filtration, multiple filtration, and activated sludge treatment are all represented by commercial installations for large meat plants. The cost of activated sludge treatment, in operation at the Kuhner Packing Company, Muncie, Indiana, is available. Removals at this plant for two 24-hour runs at 43 per cent design flow and 76 per cent design hog unit loading were about 98 per cent 5-day B.O.D. and suspended solids. The design capacities were 500,000 g.p.d. and 500 hog units, and the construction cost approximately $41,000. Operating and maintenance costs were about $13.00 per day (exclusive of fixed charges) over the first 6 months of operation. A range of costs based on the above was determined with the help of curves established for secondary municipal treatment plant costs in the Basin.

The resulting costs adjusted for land, engineering, etc. are as follows:

Design Flow Million Gallons per day	Total Installed Cost	Daily Operation and Maintenance
0.050	$13,800	$2.00
0.100	16,800	3.00
0.500	47,200	13.00
1.000	82,000	23.00

Cost of small slaughterhouse installations is based on fill and draw coagulation and sedimentation using chlorine and ferric chloride. According to E. F. Eldridge, this method of treatment has proven simplest and most effective for these small volumes of waste. A commercial installation was made by the Grand Rapids Packing Company. The cost was reported $500, exclusive of housing, for a design capacity of 5,000 g.p.d. Operating costs were not expected to exceed $1.50 per day at capacity. Removals of 88.4 per cent 5-day B.O.D. and 86.5 per cent suspended solids were obtained.

Total costs for several capacities were estimated for this process. The costs include pumping of waste and disposal of sludge to drying beds. The estimated installation costs appear considerably higher than the cost reported above, but since detail on the items included in the reported cost is lacking, no adjustment of the estimated installation costs have been made. The estimated operating costs were adjusted to conform to the expectancy noted above. The estimated costs are as follows:

Design Flow Gallons per Day	Total Installed Cost	Daily Operation & Maintenance
1,000	$350	$0.80
2,000	500	1.00
5,000	900	1.50
10,000	1,400	2.40

Corrective Measures and Costs - Miscellaneous

In some cases wastes discharging to the larger streams may be sufficiently corrected for the purposes of the particular stream by relatively simple measures such as screening, sedimentation, grease or oil separation, neutralization, and the separate disposal or treatment of parts of the waste having objectionable characteristics such as plating room wastes, etc. The same considerations hold where certain of the industrial wastes may be treated in a municipal plant after application of one of the above measures.

Measures such as flotation, neutralization and removal of salts or other miscellaneous objectionable characteristics are difficult of representation for general application to the variety of wastes and waste components encountered. These measures are applied as an independent estimate for each plant in the miscellaneous classification. In a few cases the cost of such correction is applied as an arbitrary judgment figure in the absence of sufficient detail on waste components. In most cases, however, the plant size, the probable volume of objectionable wastes, or the costs involved are relatively small and refinement in such estimates will have little influence on the cost of industrial waste treatment as a whole.

The estimated cost of the principal measures applied for partial or pretreatment are presented below.

Screening - Estimates of the cost of mechanical screening installations for cannery wastes are based on manufacturer's rotary screen ratings and costs, and on unit prices applied to pit, piping, and protective housing. About 70 to 80 per cent of the total cost represents the machine in place. In cases of basement installations this may represent substantially the entire cost. Operating costs are calculated on the basis of a cost given by L. V. Carpenter for a 100,000 gallon per day cannery as $10.00 per day for operation and disposal. The costs so estimated are as follows:

Average* Daily Flow Gallons per 12 hours	Total Installation Cost	Daily Operation and Maintenance
50,000	$1,500	$5
90,000	2,400	9
160,000	2,800	16

* Assumed as 1½ maximum flow rating of machine

Plain Sedimentation - Installation costs estimated for plain sedimentation as a partial or pretreatment measure include concrete basins, sewage and sludge pumps, and appurtenances based on recent unit prices and manufacturers' equipment costs. Installations of various capacities and detention periods ranging from 2 to 24 hours were estimated, both with and without mechanical sludge removal apparatus. The total costs of such installations, including 15 per cent for land

and engineering for a range of flows at 2 hours detention are as follows:

Waste Flow Million Gallons per 24 Hours	Cost of Basin Without Mechanical Sludge Scrapers	Cost of Basin With Mechanical Sludge Scrapers
0.05	$1,400	-
0.10	2,200	-
0.25	3,800	$5,800
0.50	4,900	7,600
1.0	7,600	11,600
2.5	15,500	22,100
5.0	26,700	35,800

Operating costs have not been included above because of the wide variation in plant operating schedules which will materially affect both power and labor cost. Estimates of operating costs will be based on the quantity of waste to be handled and upon individual plant operation.

Ponding - Diked ponds applied variously for long period detention, or as an alternative in some cases to plain sedimentation in masonry basins, or as an adjunct to cannery or steel mill treatment processes have been estimated as square, formed by earth dikes 3 ft. wide at the top, side slopes 1 on 2, 2 ft. water depth with 1 ft. freeboard, priced at $1.50 per cu. yd. in place with a lump sum of $150. for inlet and outlet appurtenances to which 15 per cent for land and engineering has been added. Since local topography and land costs play such an important part in the cost of ponding facilities the costs are likely to vary widely. The total installation

costs estimated as above, for a range of pond capacities are as follows:

Diked Pond Capacity at 2 ft. Water Depth Million Gallons	Total Installation Cost
0.5	$1,500
1.0	2,000
2.0	2,800
3.0	3,300
4.0	3,800

Connecting to Municipal Sewers - In many instances the cost of connecting to present or proposed sewer systems will be involved as a cost to the industry where municipal treatment for the industrial waste is suggested. An average distance of 500 feet and one manhole, is assumed for cost purposes.

The costs of such connections based on recent unit prices are as follows:

Rate of Flow 1000 Gallons per Hour	Total Cost of Connection
10 (and under)	$ 600
25	1,000
50	1,500

In the few known cases where pumping facilities are required, such cost is added into the connecting cost.

INDUSTRIAL WASTE GUIDES

1. Origin and Purpose

   a. Developed during the Ohio River Pollution Survey, primarily as an aid in carrying out the survey of some 1,800 industrial waste producing plants, appraisal of pollutional status, determination of treatment, cost.

   b. The more important uses:

      (1) Assistance to field engineers

      (2) Assistance in estimating loadings

      (3) Assistance in determining remedial measures and costs

      (4) Assistance in obtaining unpublished information from sources of experience on specific wastes

2. Guides prepared during Ohio River Survey (Appendix I, Supplement D, pages 1039-1228, Ohio River Pollution Control):

Brewery	Cotton	Oil Refinery
Cannery	Distillery	Paper
Coal Washery	Meat	Tannery
B-P Coke	Milk	

3. Guides in preparation in connection with present activities:

   Beet Sugar Metal

4. Topical Outline - all guides prepared on similar pattern.

   (1) An Abstract

   (2) Description of Process

   (3) Raw Materials and Products

   (4) Sources and Quantities of Wastes

(5) Character of Wastes

(6) Pollution Effects

(7) Remedial Measures

(8) Bibliography

(9) Note - taking Form

(10) Inspection Report

(11) Flow Diagram

5. Sources of information

(1) Published literature

(2) Correspondence with engineers, chemists, manufacturers, industrial management and trade associations

(3) Sampling and gaging results (Sanitary Dist. of Chicago, cooperative studies with T.V.A., State of West Virginia and the cities of Louisville and Cincinnati during O. R. Survey)

(4) Survey inspection reports

(5) Files of P. H. S.

6. Preparation of Guide

(1) First prepared in preliminary form

(2) Mimeographed copies distributed to sources of experience or familiarity in particular waste field for review and comment

(3) Final Guides prepared

7. Survey Proceedures

(1) Inspection by field engineers

(a) Note taking forms

(b) Field report

(2) Central office analysis

(a) Computation of loading each plant

(b) Tabulation by streams

(c) Examination of data on receiving water - condition, loadings, uses, etc.

(d) Determination of remedial measures

(e) Estimate of cost

8. Methods for Estimating Costs

(1) General Remedial Measures

(a) Changes within Plant - process, by-products, housekeeping

(b) Treatment in Municipal Plants - partial treatment by industry

(c) Industrial Waste Treatment Plant

(2) Installation Costs, I. W. Treat. Wks.

(3) Annual Charges, I. W. Treat. Wks.

(4) Corrective Measures and Costs - for particular types of industrial wastes

(a) Canneries

(b) Milk Plants

(c) Paper, Paperboard Mills

(d) Distilleries

(e) B-P Coke Plants

(f) Steel

(g) Textile

(h) Slaughterhouses, Packinghouses

(i) Miscellaneous - Screening, Plain Sedimentation, Ponding, Connection to Municipal Sewers

PRELIMINARY INDUSTRIAL WASTE GUIDE

Beet Sugar

Abstract

Beet sugar is extracted when warm water is passed over sliced beets. Raw sugar is crystallized out of the resulting solution.

The four major factory wastes are:

1) Flume water used to clean and transport beets

2) Process water from drainage of pressed beet pulp and from sugar extraction battery cell (diffuser) washings

3) Lime slurry from the juice filters

4) Steffens waste, the residue from the recovery of sugar from molasses. The wastes vary in strength from Steffens waste having a five day 20°C. biochemical oxygen demand of 10,000 ppm to flume water having a biochemical oxygen demand of 200 ppm. The medium strong wastes, process water and lime water have a biochemical oxygen demand of 1250 ppm and 1750 ppm respectively.

The waste flow per ton of beets totals about 3100 gallons and consists of (a) 72.1% flume water, (b) 21.6% process water, (c) 2.4% lime drainage, and (d) 3.9% Steffens waste. Plant capacities vary from 600 to 2000 tons of beets processed per day.

In many instances wastes are disposed of by simple dilution in surface streams. Pollution abatement measures which may be applicable are treatment, re-use of water, process water discharge elimination and utilization of Steffens waste.

By products are beet pulp, filter press cake and molasses.

PRELIMINARY INDUSTRIAL WASTE GUIDE

Metal Industry

Abstract

Metallic parts are commonly plated or coated for protective or decorative purposes. Processing usually involves: (1) cleansing or degreasing; (2) pickling in acid to remove rust, mill scale or other metallic oxides; and (3) application of the plating or other coating. In some cases an additional heat treatment in a molten cyanide bath is given.

Although all these processes result in wastes which may be detrimental to the natural waters, those wastes of primary concern in stream pollution are the spent pickling liquors, including the rinse following pickling, and the toxic cyanide and metallic wastes resulting from plating and coating operations.

Pickling liquor contains one or more acids and their metallic salts (e.g., H_2SO_4 and $FeSO_4 \cdot 7H_2O$). If discharged to municipal sewerage, it may cause corrosion and inhibit biological processes utilized in the oxidation of sewage and the digestion of sludge. When discharged without treatment into a stream providing inadequate dilution it discolors and acidifies the water, depletes oxygen and blankets the bottom with sludge resulting from oxidation of certain metallic salts.

Wastes from plating and coating processes frequently contains cyanides and metallic substances toxic to fish and other aquatic life. If such wastes are admitted to municipal sewerage, they may seriously affect the biological treatment processes.

Since the principal pollutional effect of the metal industry wastes is acidity and toxicity, population equivalents, expressed in terms of biochemical oxygen demand, are not significant. Comparative pollutional effect must be expressed in terms of total acidity, relative toxicity, or similar terms.

The raw materials used and the processes employed depends on the base material and desired product. They even vary considerably in different plants producing a similar type of product. Certain type processes are included herein, but emphasis should be placed on a thorough study of each individual plant to determine the quantities and characteristics of the various wastes involved and how their pollutional effect may best be reduced or eliminated.

At present economic recovery or reuse of metal industry waste liquors appears impractical on any large scale. A few plants produce by-products, such as copperas, building and insulating material, paint pigments or other products, which at least reduce cost of treatment processes. In most cases remedial measures must consist of good housekeeping and waste treatment. Some of the present methods of disposal or treatment for pickling liquor and other acid wastes are controlled rate and time of discharge, lagooning, neutralization with lime or other alkaline material. Removal of cyanide from liquid wastes has been accomplished by acidification and an agitation, excess lime treatment to form insoluble salts, conversion to thiocyanates with sulfur compounds, use of oxidizing agents, such as chlorine, to form cyanates. Metallic salts have been removed by precipitation with excess lime; and hexavalent chrome, by treatment with ferrous sulfate, iron filing contact chamber and sulfur dioxide treatment.